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Abstract

This paper examines technology introduction on ships guided by three questions: 1) what drives technology introduction; 2) how seafarers are involved in the process; 3) what the consequences are in shipping. The data were collected through semi-structured interviews with ship managers and senior seafarer officers as well as a questionnaire study with seafarer officers. They reveal a discrepancy between the regulatory intention of technology introduction and the actual implementation process on ships. While the former is spurred by safety concerns, the latter is driven by economic rationality. This discrepancy makes technology a double edged sword in shipping. On the one hand, it plays an important role in improving safety, and on the other, it brings about work intensification and increased surveillance at workplace.

Key words: fatigue; paperwork; shipping; technology; work intensification

1. Introduction

Shipping plays the central role in global trade by handling over 80% of the share by volume. As seaborne trade rapidly grows in tandem with world trade and world GDP, the maritime shipping industry finds itself in the forefront of several changes including in the adoption of various new technologies (see Table 1 for major technologies introduced on ships). In the last 20 years, in the navigation side, for instance, ships have been fitted with advanced technologies in global position fixing and anti-collision avoidance. Likewise, in the engineering side, ships are far more automated and offer greater direct control of the engine from the navigation deck; while in the cargo operation, increasingly there is more automation to achieve remote centralised monitoring and operation. Technology has also found its place in advancing communication between the ship and its shore-based managerial counterpart by bringing the cost down and facilitating greater and more readily accessible forms of interaction. From the days of wireless transmission and waiting to interact till the ship calls a port, the industry now freely uses satellite technology and the ship is now easily reachable at the other end of the phone even when it is in the middle of an ocean. These technologies help automate shipboard operations, and thus can be seen collectively as automation technology.

Acronyms	Full names
ARPA	Automatic Radar Plotting Aid
GPS	Global Positioning System
GMDSS	Global Maritime Distress and Safety System
AIS	Automatic Identification System
ECDIS	Electronic Chart and Display Information System
UMS	Unattended (Unmanned) Machinery Space
OWS	Oily Water Separator

Table 1. Technologies introduced on ships

Shipboard technology adoption not only serves to improve efficiency and productivity by automating operations, but also is intended to help with safety management and pollution prevention. The shipping industry is highly safety critical as a failure of either a technological or a human kind resulting in an accident carries the risk of causing damage to property, loss of life and pollution with noticeable consequence. Hence, preservation of the environment and safety management are closely reliant on successful ship-board operations. When a piece of technology is implemented for improved ship-board operation it carries the promise of making shipboard operation safer and help prevent pollution (Lorange, 2001; Lyridis et al., 2005; Panayides, 2003).

Despite the potential benefits, it is evident from maritime accident investigation reports that inadequate use of technology on ships is a common contributory factor to accidents (Tang et al. 2013). In this context, a number of studies have been conducted to examine issues, such as training on shipboard technology (Bailey et al. 2008; Sampson and Tang 2016; Tang and Sampson 2017), seafarers’ perceptions of new technology (Alan 2009), and limitations of technology on ships (Lutzhoft and Dekker 2002). They revealed that while seafarers need skills and knowledge on operations and limitations of new technology, the industry in general is reluctant to invest in training. These studies however took technology as pre-given and focussed on issues related to the post-implementation stage; and as a result, issues involved in the adoption stage and implementation processes remain to be explored. In this context, this paper takes a holistic approach, examining all the three stages of technology introduction on ships. More specifically, it explores three related questions: 1) what drives technology introduction; 2) how seafarers are involved in the process; 3) what the consequences are. Similar to the previous research, technology in this paper refers to automation technology on ships in general.

2. Literature review

2.1 Technology introduction and safety

This paper (and the three questions) builds on three bodies of literature on technology introduction. The first one focuses on the benefits of technology. In safety critical industries research evidence indicates safety benefits of new technology (Brenner et al. 2016; Parente and McCullough 2009). In aviation it has been reported that successful use of safety-enhancing technology has improved safety for human-centric interfaces along with airborne and ground-based systems (Darr, et al., 2008). The National Aviation Safety Strategic Plan of the US Air Transport Systems (JPDO, 2004) claims that technology helped achieve safer practices and emphasises how technology helped in an integrated and systematic approach to safety risk management. Likewise, in the medical sector, increase in the application of information technology has improved safety of drug usage especially in reducing medication errors in hospitals (Bates, 2000). Bar coding of drugs, automated dispensing devices to ensure that a drug is dispensed to the correct patient and using computers to enter the drug requirement have all successfully assisted the medical practitioners. It has also been reported that computerised intervention in the anti-infective drugs management program improved quality of patient care as well as in the reduction of cost. By managing information on patients' allergies and antibiotic-susceptibility mismatches, the use of technology has greatly reduced errors and improved the quality of patient care (Evans et al., 1998).

Despite the potential benefits, technology introduction is rarely problem free. Therefore, a second body of literature examines the introduction processes. It is pointed out that to achieve more successful implementation, technology should not be seen as merely an additional piece of hardware which independently affects work performance; rather, it is the interaction between social and organisational reality and technological factors that shapes how work is performed (Karltun et al. 2017; Noy et al. 2015). Several recent reviews of literature on health information technology (HIT) adoption (Cresswell and Sheikh 2013; Greenhalgh et al. 2017; Sligo et al. 2017) revealed a number of technological, social and organisational factors facilitating HIT implementation. In terms of technology itself, it should be fit for purpose and easy to use. A number of social factors are equally important, including technological competencies of users, personal and peer attitudes towards new technology, and the environment for peer learning. As the interaction between users and technology takes place in organisations, organisational factors are crucial, such as strong leadership, effective communication across the organisation, sufficient resources allocated to training and on-going help-desk support, involving users at all stages of implementation, and on-going evaluation and user feedback. More importantly, it is argued that the key for successful implementation is to ensure the fit between technical, social and organizational factors (Cresswell and Sheikh 2013; Sligo et al. 2017).

Similar to the first body of literature, the third one also focuses on the impacts of technology. But it takes a critical approach to examine the consequences technology adoption on workers. It reveals that technology makes work increasingly routinised, mechanised, and automated, which in turn deskills workers and even replaces them (David and Dorn 2013; Frey and Osborne 2017). Furthermore, routinisation and automation reinforces management control of the labour process (Braverman 1974), and new information technology enables management to monitor the labour process in more detail (Fleming and Sturdy 2011; Bain and Taylor 2000; Bain et al. 2002). Technology also contributes to work intensification via various management techniques, such as scientific management in the past and lean production more recently (Bain and Taylor 2000; Bain et al. 2002; Carter et al. 2011; 2013; Green 2005). Lean production, for example, in theory aims to continuously improve efficiency and quality by eliminating wasteful time and processes; but in practice it was found to increase both volume and pace of work, and consequently workers complained about increased work intensification and pressure (Carter et al. 2011; 2013).

Technology introduction in shipping is similarly associated with work intensification as automation on ships led to reduction on manning levels (IMO 2001). For example, the average crew size of Australian merchant navy fleet was reduced from 35 in 1982 to 16 in 1994 (Morris and Donn 1997). At the same time, technological advances in cargo handling have made port turnaround time shorter. In one typical port, the data suggested that vessel berth time on average was reduced from 138.50 hours in 1970 to about 15.75 in 1998 (Kahveci 1999). Even though technology makes some ship operations less demanding, it can hardly replace manpower in berthing and un-berthing operations. The double reduction means that there are fewer people to do the same amount of work in less time, which inevitably results in work intensification and fatigue. While fatigue is an occupational health issue, it has serious consequences on safety and it is not uncommon that duty officers fell asleep (due to fatigue) while on watch which resulted in grounding accidents (Tang et al. 2013).

Each of these three bodies of literature focuses on one aspect of technology introduction at workplace. Rather than incompatible, their differences in terms of focus, findings and implications reflect the widely acknowledged conflicts between safety and productivity at workplace (Carayon et al. 2015; Woods 2007). As Carayon et al. (2015) point out, 'what is espoused by senior management in terms of safety priorities does not reflect how safety-productivity trade-off decisions are actually made in the normal course of operations.' This conflict is strongly evident in the shipping industry (Xue et al. 2017; 2018). Arguably, it has impacts on technology introduction on ships, especially on the fit between technical, social and organizational factors. By examining the three stages of implantation, this paper will draw out these impacts and help develop a comprehensive understanding of issues related to technology introduction on ships.

Furthermore, while the second body of literature largely focuses on technological, social and organisational factors, it also acknowledges that external environments, such as regulations, policies and industrial norms, may also condition technology introduction (Carayon et al. 2015; Cresswell and Sheikh 2013; Sligo et al. 2017). Therefore, this paper also examines the role played by the industrial wide environment. The next sub-section provides a background of the industry.

2.2 The global shipping industry

Until around the late 1960s, the majority of ship-owners registered their ships in their home countries and employed local seafarers. As such the ship-owner, his or her ship and the seafarers sailing on it all had the same national identity. However, from the 1970s, as a consequence of deregulation and increased free-market capitalism, more and more ship-owners chose to register their ships in countries, such as Liberia, Panama, and Bahamas, known as the flags of convenience (FOC), which offered lucrative registration fees, minimal conditions for admission and comparatively relaxed regulatory standards (DeSombre, 2006).

Furthermore, as FOC did not impose any restriction on the nationality of seafarers, the ship-owners increasingly employed low-wage seafarers from new labour-supply nations, such as East European, and East and South East Asian countries. These seafarers were employed on short-term contracts and the majority of them ‘worked on contracts covering a single voyage or tour of duty’ which was typically between five and twelve months. The arrangement also meant that the employers no longer had the obligation towards seafarers’ continuing employability (ILO 2001).

In this way ship-owners consolidated their economic advantage by engaging in increased cross-border activity and exploitation of various resources. Consequently, flagging out gave rise to a global seafarer market. As a result of this transition the industry also witnessed new types of ship owners who had little experience of managing ships which subsequently led to a growth in the independent third party ship management companies taking on the responsibility of asset management and looking after the day-to-day operational needs of the ships (ILO 2001). The industry in its current form is deeply fragmented with over 70% of the ships registered under FOC and a similar percentage of seafarers employed from low-wage labour supply nations.

3. Research methods

The study started with semi-structured interviews with ship managers and seafarers in South Asian country. Three shipping organisations with different operation styles were involved (see table 2). The rationale for engaging with different types of operators was to determine if that had an influence in the implementation of technology. As argued by Stake (2000) organisations for research should be from the mainstream and not selected randomly – these three organisations reflected purposeful sampling which included a fair balance of the operating features in the three companies.

	Company A	Company B	Company C
Operation	Local branch office of a globally operated 3rd party shipping management company	Local branch office of a privately held ship owning company based in Western Europe	State owned shipping company – managing own and 3rd party ships
Types of ships	Tankers, bulk carriers, & general cargo ships	Tankers only	Tankers, bulk carriers, containers, passenger ships & offshore ships
Number of ships	Around 100	Around 50	Around 75
Crew nationality	Multi-national	Multi-national	National
Interviewed managers	5	3	4

Table 2 Details of the organisations and participants in the qualitative study

Semi-structured interviews with the managers in their offices provided the opportunities to appreciate the underlying issues, such as the constraints and the influence, affecting their chosen procedure for implementation of technology. All participants were encouraged to share their views and operational experiences more widely and not limit the discussion to the core focus of technology implementation.

Apart from the managers from the three companies, four serving senior captains and chief engineers were interviewed for their experiences of technology introduction in the industry. They offered a different perspective to complement that of the managers. These senior officers were not employees of any of these three companies, but all of them worked on tankers with advanced automation technology. The underlying rationale is that were they employees of any of these companies, the knowledge that the shore staff of their company were part of the same study might discourage them from expressing their views freely.

The following were among the questions asked to the participants about their experiences:

- What drives the technology implementation process?
- How do you justify the cost of implementing technology?
- Describe the role of the ship's staff in the implementation process?
- Is technology optimally implemented for improving safety of the ship and OHS of the staff?

Each of the 16 interviews lasted between 45 and 90 minutes and was digitally recorded with the permission of the participants. The interviews were transcribed and coded by the first author. Themes and their relationships were drawn out from the data by the first author in discussion with the second author (see Figure 1 for an overview of the relationships between themes). Similarities, inconsistencies and variances between views expressed by ship managers and those of seafaring staff were also examined.

Following on the themes drawn out of the interview data, a questionnaire was designed and administrated to seafarer officers, who were undertaking training courses in maritime colleges in India, Philippines, and the UK. The aim was to verify interview findings. Altogether, 134 questionnaires were completed and returned. Sixty nine of the participants came from India, 44 from Philippines, 11 from Vietnam, four from Spain and the rest from other countries. The participants either were junior officers, with watch keeping responsibilities on ships, such as the second officer, or were senior officers, such as the chief engineer with supervisory functions.

The questionnaire asked 22 technology implementation related questions using Likert scale against each question, starting from *Totally disagree, Disagree, Neutral, Agree* to *Strongly agree*' (see Appendix for the questionnaire). Due to the limited space of this paper, the responses to only a few of these questions were used to support the interview data. The research was conducted in compliance with the ethics guidelines and approved by the Faculty Research Ethical Approval Committee (FREAC), Faculty of Business (Ref. No. FREAC1213.51). All the research participants gave their informed consent.

4. Results and discussions

This section presents and discusses the results in relation to the three questions set out in the beginning. The first sub-section discusses the drivers of technology introduction, and the focus is on the adoption stage. The second sub-section focuses on the implementation process and discusses seafarers' involvement in the process. The consequences of technology introduction are discussed in the third sub-section. Figure 1 shows the main themes and the flow of the discussion.

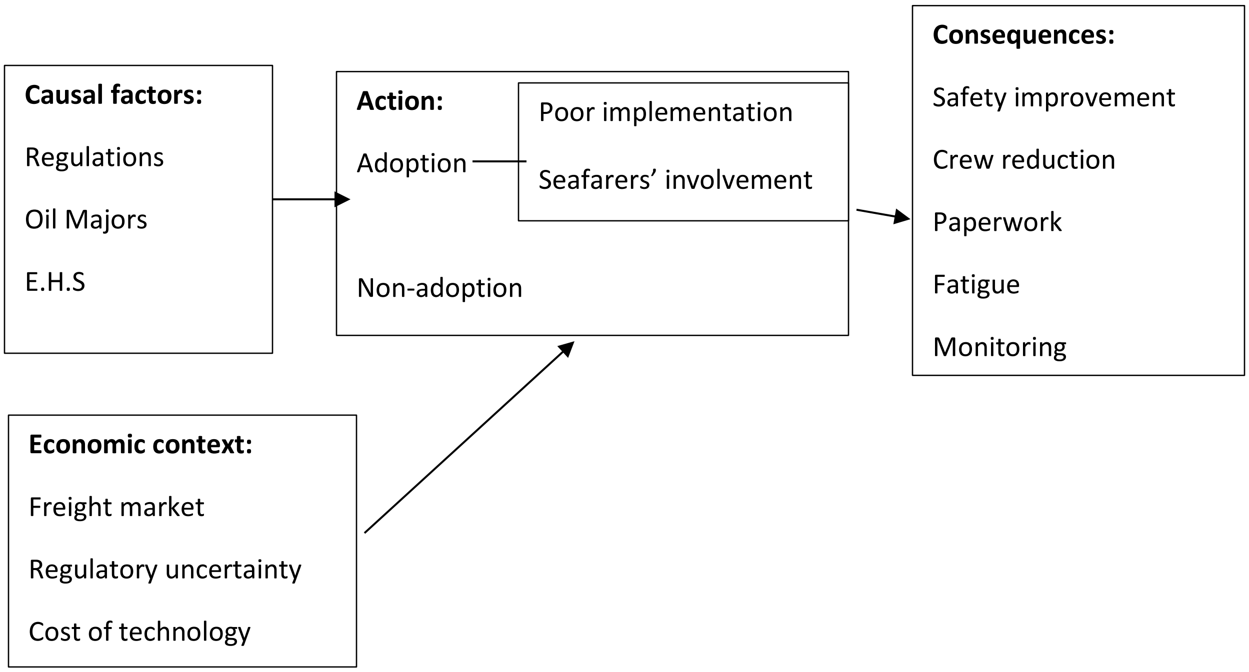

Figure 1. Relationships between themes

4.1 The economics of technology introduction

In the tanker trade a critical driver for adopting new technologies is the Oil Majors, which refers to major oil companies in the world, such as Shell, Texaco and Exxon. They dominate the oil supply chain from exploration and production of crude oil to refining, as well as to distribution of refined petroleum products. Although it is a vertically integrated supply chain, some of its elements including the maritime transportation are outsourced. However, as Oil Majors remain implicitly associated with the ship which carries its cargo, they take active interest in the operating and safety standards of ships they hire and in the shipping companies where the ships are managed. This is because shipboard incidents have the potential to bring them to disrepute and likely to result in their wider economic loss. Thus, Oil Majors lay their own operating standards and before employing a ship they conduct rigorous vetting to determine the physical state of the ship as well as its operating practice against such standards. Their special requirements often include the use of new technology on ships which are over and above the regulatory requirements. Thus, for a higher charter fees the shipping companies which trade oil major cargo invest higher than the globally acceptable minimum standards (see Bhattacharya and Tang 2013; Tang and Bhattacharya 2018).

Other than the prescribed demands from the Oil Majors, the uptake of technology is left to a combination of push factors from the regulators and the discretion of the ship owners to do so voluntarily. New regulations are developed through deliberation at the International Maritime Organisation (IMO) by individual States and industry stakeholders. The most common influencing factor for any such new regulation is to improve maritime safety. The IMO has the aim to implement new regulations uniformly across the industry so that a common platform is established for ships sailing to all corners of the world to have a minimum threshold of safe operation. However, it also means that such regulations come into effect after lengthy negotiations between flag States and industry stakeholders and are aimed at the level which is realistically achievable by the states which have relatively weak infrastructures. The IMO led regulations thus draw criticism for being slow and offering only a step change in particular to technology uptake (Roe 2013).

The process provides ship owners the opportunity to voluntarily adopt technology before the regulatory deadline and offers flexibility to choose how to implement it. The reality, however, is that safety consideration, which is the underpinning objective of bringing in new technology to ships, is replaced by an economic justification. The most predominant sentiment from the managers' perspective is the challenge to justify adoption of technology for enhancing safety which is not duly supported by an economic rationale. This understanding was shared among all three companies. Despite the differences in their management styles, adoption of technology for improving safety alone was not a strong enough justification. A manager from Company A expressed:

> Progress however gets hampered by the question of 'who should pay' for these investments and there was a need to provide evidence of payback from innovations.

The problem of who should pay, however, was not a concern when the technology was demanded by the Oil Majors. It was because their chartering fees were adequate to pay for the investments.

As all organisations operated tankers, this view was common across all three of them. One manager from Company C, for instance, said:

> Oil Majors… if they require a piece of technology to be installed then of course we don't have to think twice – this is different you see… then we know we have to and no one needs convincing.

When Oil Majors are not involved, however, the reality is different. The volatility of the shipping market involving a range of uncertainties makes it even more difficult for the ship owners to judge the market and make an investment (Lorange 2001). While they are willing to adopt new technology, an economic analysis of the cost of implementing any new piece of technology is seen as a prerequisite. When regulation is not driving the technology the matter gets even harder. One manager from Company B explained:

> Regulatory changes were not always clear and industry generally is anxious not to be taken down 'a blind alley'… now unless there is regulatory directive towards new technology voluntary investment is very difficult to justify.

It is a popular saying that 'safety pays'. According to this logic, if technology helps with management of workplace health and safety and environment, then it pays back in the long run. In practice, however, such message tends to be treated as merely a slogan and appears unable to convince ship managers. One ship captain, for example, said:

> With the kind of awareness generated, it is today a well-known fact that what is good for EHS [Environment, Health and Safety] is good for business and vice versa, although returns may be not as tangible for companies to voluntarily adopt technologies contributing to it… There is where we fail to convince our managers on how important new technology is.

The structure of the industry in part plays a major role here. Flagging out has for years encouraged ship owners to cut costs by opting for lower registration fees and tax, more relaxed regulatory requirements, and cheaper seafaring labour from the global market. Such cost cutting measures inevitably led to lower quality of ships and particularly to the less scrupulous ship-owners an important competitive edge. This edge puts pressure on those who operate higher quality ships with higher operating costs, especially when the shipping market experiences crisis and freight rates go down. Meanwhile, cost cutting allows low quality ships to survive and delays the elimination of substandard tonnage, which in turn makes oversupply of tonnage an issue difficult to solve and further depresses freight rates (ILO 2001). Thus, there is a vicious circle of cost cutting in the industry facilitated by the structural change. But fortunately a few pieces of regulations adopted at the IMO in the 1990s to improve safety records and a series of regulatory enforcement mechanisms, such as Port State Control (PSC), have combatted substandard ships (ILO 2001; DeSombre 2006), and this vicious circle has not resulted in a race to the bottom. It provides no incentive for a race to the top either, and as a result staying in the middle became the commonplace (DeSombre 2006; 2008). Staying in the middle means that any initiative to raise standard may lead to a disadvantage in the competition. While substandard ships operating at the lowest possible costs would be targeted for inspection and thus penalised, keeping costs at or slightly below an average level is safe and remains important for survival.

In the light that the fierce global competition and the volatile freight market make future less predictable and more uncertain, it seems difficult to maintain a long-term view in the industry and ship managers and owners tend to pursue short-term returns and cost cutting. Thus, it is not surprising that despite the differences between the three companies, they were remarkably similar in taking no initiatives in investing in and adopting technology voluntarily. Unsurprisingly, according to the questionnaire data (see Table 3), more than half (50.8 per cent) either agreed or strongly agreed that ‘economic logic of low cost operation underpins every aspect of technology integration’.

	Totally Disagree/Disagree	Neutral	Strongly Agree/Agree
Economic logic of low cost operation underpins every aspect of technology integration	12.5%	36.7%	50.8%
Implementation of technology leads to downsizing of crew	23%	26%	55%
The ship staffs are consulted for the design, operational constraint or impact of new technology	43%	22%	35%
The seafarers on the ship directly influenced technology implementation	40%	27%	32%
Shipboard paperwork has reduced due to technology implementation	49%	14%	36%
On current (last) ship Technology was complex and confusing	4%	13%	83%
Communication technology helps the managers monitor the ships more than it benefits the seafarers	11%	22%	67%

Table 3. Impacts of implementing technology on shipboard operation (n= 134)

4.2 Poorly planned implementation

As ship owners found it hard to justify investment in technology it remained largely driven by external forces such as pressure from powerful business clients and regulatory mandates. The enforced nature of introduction provoked reluctance which was reflected by the common practice of leaving it to the last minute, as one manager from Company C mentioned:

> Early planning for effective induction of new technology is important… Leaving it to the last moment is another well-trodden path within our industry… but that's how ship owners operate.

Research evidence suggests that when new technology is introduced, comprehensive integration of human operators starting from the definition and early stages of design to development and evaluation in the use of technology should be considered for its optimal use (Cresswell and Sheikh 2013; Karltun et al. 2017; Noy et al. 2015). It points out the importance of giving greater consideration for the capacity, limitations and needs of the operators and the environment they work in as well as their aptitude, skills, training in the use of the technology, and the impacts it may have in their safety and health at workplace. Similarly, studies in the shipping industry have also identified the need for better coordination between humans and machines (Lutzhoft and Dekker 2002) and adequate training for operators (Allen 2009) for a more fruitful implementation.

The ship managers interviewed were aware of these concerns, despite the prevalent practice of leaving to the last minute. They also held the opinion that comprehensive and early planning involving managers and seafarers in the initial introduction of new technology and in training of end-users would be ideal for effective implementation. One Company C manager said:

> Firstly planning is the key. Understanding the ship's staff, their capabilities, their needs, aspiration and complete familiarisation helps… even simple things such as where should the new piece of technology be installed or where should the display unit be located in the bridge should be inquired from the users.

The focus on short-term economic returns, however, is not compatible with early and careful planning. The seafarers in their interviews expressed lack of involvement in any of the stages leading to the implementation of technology on ships. They revealed that the practice was to add automation as and when it was pressurised by the commercial players or became mandatory as per statute. Such changes were typically brought in when the ship was in for routine maintenance and seafarers were required to learn the operation quickly and adapt to it. One chief engineer explained:

> We are constantly adapting to the newest technology. No one asks us of what technology should be invested in or discusses whether a technology is relevant to the design of the ships… every now and then there is either a new technology or a new model that the managers decide to install.

Similarly, one captain stated in the interview:

> Seafarers have no choice but to cope with the situations of given technology, as they are bound to deliver on ship's performance.

Thus, for seafarers, technology is pre-given and their involvement in the implementation is to accept and cope with it. It was not just the seafarers' views, the lack of seafarers' involvement was all too well known to the managers in the three companies, despite the organisational differences. One of them from Company A, for example, candidly commented:

> I am not convinced that with the introduction of all of the technologies over the decades ships have become any safer. We can keep blaming the new generation of officers on relying too much on technology or failing to use the technology properly but the truth is that by adding non-standardised technology often without consulting the seafarers or without giving them adequate training we may have caused them more harm than good.

According to the questionnaire data (see Table 3), 43 per cent of the respondents totally disagreed or disagreed with the statement that 'The ship staffs were consulted for the design, operational constraint or impact of new technology', and 40 per cent totally disagreed or disagreed with the statement that 'The seafarers on the ship directly influenced technology implementation'.

4.3 Demanding technology

While seafarers in their interviews acknowledged a few benefits of using technology, such as safer navigation under adverse weather which would have been far more challenging otherwise and faster and more convenient communication leading to quicker dispatching of stores, they expressed overwhelming concerns with the 'ruthless reduction of manpower' on ships and the issue of work intensification and fatigue caused by it. While the interviewees showed their awareness of the deterring cost of seafarers' salaries and the trend in the industry towards downsizing, they were of the view that 'proper' use of technology could benefit them as users and could offer a solution to the concerns of work intensification and fatigue. However, the interviews further revealed that in reality instead of contributing to safer and simpler operations, new technology introduction made work on-board more demanding.

Since economic considerations take the central stage and safety recedes to the background in the technology introduction process, none of the managers made reference to seafarers when talking about driving forces of technology introduction. They, however, mentioned the need for reduction in crew size as an inevitable outcome because the cost of the expensive technology had to be recovered. One of the senior managers in Company A expressed candidly:

> Each piece of technology is expensive and comes with a promise of cost reduction and efficiency…no sooner than GMDSS was installed the ship-owners got rid of the radio operators. But in reality the radio operators did a lot more than sending and receiving messages. But saving an officer's salary for 12 months was as though the precondition for installing the system. Now the Master is required to do all that… the ship is not necessarily any safer, but who cares?

Surely, this happen not only to Company A; the position of radio officer/operator on ships has been removed in the whole industry as a result of GMDSS introduction.

Seafarers too offered some scathing remarks on downsizing as after all it was they who had to bear the brunt of the reduction in shipboard manning. Some even suggested that implementation of technology was in fact a ploy to reduce the expenses on manpower. A Chief Engineer articulated this point of view and argued:

> Regarding the highest cost to ship owners being crew wages...they are *not* the highest operating cost, but they are the highest *discretionary* cost. In other words, ship repair, dry-docking, fuel, etc. are all non-discretionary costs because they are overhead costs that are outside the ship owners' area of control. They can't make the ships use less fuel, but they can cut the number of crew on-board and still make it to their destination.

The questionnaire data (see Table 3) also indicated a similar result in which 53 per cent either agreed or strongly agreed with the view that downsizing on ships was a result of technology addition.

Another concern seafarers pointed out is related to paperwork. It is a common complaint in the industry that the amount of paperwork has increasingly become a heavy burden for seafarers (Knudsen 2009). In shipping, the Netherlands Organisation for Applied Scientific Research (TNO) Report (2005) strongly suggests that on-board information and communication technology (ICT) developments hold the potential to increase efficiency and reduce administrative burden thus relieving seafarers from, for example, filling forms and logbooks by recording and transmitting real-time operational data to the management office and making the industry safer. However, around half of the serving seafarers in the questionnaire study disagreed or totally disagreed that by introducing technology, paperwork on board had reduced.

Seafarers in the interviews complained that technology that could help reduce paperwork burden had not been considered in the industry and expressed the hope that one day introduction of such technology on-board would become a reality, as one seafarer mentioned:

> We have not seen any reduction in the paperwork despite the increasing application of technology on ships… the maritime industry should be encouraged to widely adopt

> electronic data storage and get rid of the paper burden whenever possible. [Hopefully] it should be a matter of time that there is common acceptance of electronic checklists.

At the current stage, however, rather than reducing paperwork, introduction of new technology served to increase it. Seafarers explained the practices of duplicate log keeping which required watch-keeping officers to manually enter data to one or more logbooks from the readouts of shipboard machines and instruments. They complained that the time saved by having an extra instrument for more efficient ship operation was lost due to the additional workload it generated. A captain, for instance, said in his interview:

> On the bridge we still spend half of the time filling in logbooks and sheets which need meticulous filing at the end of the day. Often we are merely noting information from the instruments and machines to prove that we are monitoring them. Surely, the intention of the use of technology was not to disturb the [watch-keepers from keeping an uninterrupted] lookout.

A Chief Engineer likewise expressed:

> P&I Clubs are reporting growing number of accidents in which fatigue was identified as a major contributor. There is a need to 'work smarter', perhaps through task analysis that will assess the optimum manpower needed for tasks and voyages… but the current practices of technology use are not relieving our tasks. They are only adding to it.

Over the last three decades emails and phone calls as means of communication between a ship and its management office have become relatively inexpensive and thus resulted in increased and more frequent information exchange between the ship and the shore. Such convenience brought about by technological development ironically also serves to add seafarers' workload, as managers ashore demand for more and more information from ships. In the interviews the officers shared their disapproval because of the demands made by the managers to convey operational data, such as the details of fuel consumption or ship's location and maintenance reports from the ships, as one captain put it:

> There is so much time and effort being taken up in this process of 'Monitoring of fuel consumption and vessel performance'. There are daily reports, weekly reports, monthly reports, quarterly reports, half-yearly reports besides the special reporting that are not at fixed intervals. The Master today is not the captain anymore, he is a clerk.

At the other end, the managers were aware of seafarers concerns but justified the increasing demand for information by expressing the need for keeping a better check on their seafaring colleagues. They were keen to use the technology to monitor what went on their fleet. One manager in Company A, for instance, said:

> In the backdrop of popular crewing policies and the basic education and training infrastructure in non-established countries that supply most seafarers, this [seafarers working more independently] was impossible. Without the right tools, we cannot expect our people to make difficult management decisions… we have to monitor them, guide them and talk to them on the phone every now and then.

The data seem to suggest a process of deskilling as managers made the decisions while ships' staffs were required to pass on relevant information. This, however, was not the only interpretation, as interviews with seafarers revealed their claim that the managers were using new communication technologies primarily to control the activities of the shipboard staff but were not prepared to assume more responsibility. One captain pointed out:

> The Captains still have to take all the tough decisions as they are on the spot; the managers would never take any responsibility… they would only call and ask questions but back off when things get tough.

As such, seafarers did not welcome such monitoring and interfering in the management of shipboard operation. After all, it increases their workload without reducing their responsibility. In their perception ICT had deprived them of their freedoms of being independent at sea. One captain said:

> While ICT has made it cheaper to call our families the superintendents use the same technology to play Big Brother by calling ships several times in a week… calling up for ETA [estimated time of arrival], asking questions on requisition orders sent form ships, asking about progress in the maintenance and hundreds more.

In the same way, the questionnaire data showed that two out of every three seafarers either agreed or strongly agreed that on board ICT was used more for surveillance purpose compared with the benefit it brought to the seafarers.

Clearly, seafarers disapproved such technology-led control as they have traditionally been rather independent from the time the ship left the harbour. In part, the disparity between the two perspectives reflects a poor level of mutual respect, understanding and trust. Such distrust, as the manager's word above implied, is rooted in crewing policies which is characterised by short-term employment. The major point here is that for seafarers, the introduction of ICT facilities did not take away any of their responsibilities but instead made managers more demanding on them.

Furthermore, seafarers in the interviews expressed that managers' demand could actually be satisfied by technology easily, as one chief engineer suggested:

> If we have to operate with so few [crew], we must concentrate only on the core operational activities. The tasks that involve reporting the mere volume, temperature, pressure and things like speed and location should be automatically transmitted without us having to bother.

However, such technology is not yet in demand. Without regulation, initiating introduction of such technology to spare seafarers from time-consuming and tedious clerical tasks of reporting activities would be hard to justify as the prevalent focus in the industry on short-term economic returns is far too ingrained.

5. Conclusion

This paper examines the three stages of technology introduction on ships guided by three research questions. It shows that the main drivers of technology adoption in shipping are the Oil Majors and IMO regulations. Out of economic considerations and due to competition pressures, voluntary technology adoption to improve safety is rare. In order to reduce costs, the implementation of new technology is often rushed without adequate planning. As a result, users – seafarers – are not consulted in the process, training is haphazard and user feedback is not sought and concerns not addressed. Although new technology does bring some safety and operational benefits, it nevertheless creates additional but unnecessary paperwork which sometimes makes seafarers fatigued. It also results in reduction in crew sizes and increased workplace surveillance.

Thus it is fair to say that new technology introduction on ships has not been successfully integrated into the work process. Underpinning this outcome is the tension between (long-term) safety and (short-term) economic gains at workplace (Carayon et al. 2015; Woods 2007). While the technology introduction is driven by regulatory mandates and powerful clients for the purpose of improving safety and protecting the marine environment, the implementation process is driven by economic logic of low cost operations with safety concerns being pushed aside. Such discrepancy between the regulatory intention of technology introduction and the actual implementation process on ships means that while technology helps, the benefit is undermined by new problems. In theory, new technology holds potentials to lessen seafarers' stress and fatigue, but in practice they contribute to it by making users adapt to the new technology without alleviating their manual tasks.

Despite the differences between the three companies involved in this study, they are similar in their approaches to technology introduction. This is largely due to the globalisation of the shipping industry, which means the companies are regulated by the same regulatory agencies and compete with each other directly in the global market for freight. Even though Company C, a state-owned national company, employs national seafarers only, this crewing policy does not give it any advantage over the other two companies who use a multi-national crew, because this South Asian country is a major cheap seafarer labour supplier. The three companies converge in their competitive strategy which is cost reduction. In fact, cost reduction is the prevailing competitive strategy in the shipping industry (Ferfeli 2009; ILO 2001). This strategy contributes to the (over)emphasis on short-term economic gains at the cost of long-term safety benefits.

The logical way to resolve the tension between economic gains and safety is to make the principle – safety pays – work. However, it remains a challenge as the global structure of the shipping industry and its cost-cutting based competition forces shipping companies to prioritise short-term economic gains. This challenge also reveals that factors affecting technology implementation often go beyond the level of organisation.

As this paper focuses on three companies from a single nation, it has limitations. While the findings serve to highlight a number of issues, some other issues may not surface in this study. Further work is needed to examine technology introduction on ships in other contexts in order to develop a more nuanced and fuller picture.

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Appendix: Technology Implementation on Ships Questionnaire

1	What is your job title?		
2	Which company do you work for?		
3	How long have you been working in this (a) company, (b) rank	(a)	(b)
4	How old are you		years

5 Is your Tech Manager the

- Ship Owner ○
- 3rd Party ○

Other (Please specify):

6 Is your Crew Manager the

- Ship Owner ○
- Tech Manager ○
- 3rd Party ○

7 Economic logic of low cost operation underpins every aspect of technology integration.

Totally disagree — Strongly agree

1 ○ 2 ○ 3 ○ 4 ○ 5 ○

8 Only minimum compliance to technology is sought that is pushed through regulations.

Totally disagree — Strongly agree

1 ○ 2 ○ 3 ○ 4 ○ 5 ○

9 The ship staffs are consulted for the design, operational constraint or impact of new technology.

Totally disagree — Strongly agree

1 ○ 2 ○ 3 ○ 4 ○ 5 ○

10 Design is led by technology and its commercial exploitation rather than to meet user needs.

Totally disagree — Strongly agree

1 ○ 2 ○ 3 ○ 4 ○ 5 ○

11 The flag of the ship directly influences the standard of technology implementation.

Totally disagree — Strongly agree

1 ○ 2 ○ 3 ○ 4 ○ 5 ○

12 The owner of the ship directly influences the standard of technology implementation.

Totally disagree — Strongly agree

1 ○ 2 ○ 3 ○ 4 ○ 5 ○

13 The Tech Manager of the ship directly influences the standard of technology implementation.

Totally disagree — Strongly agree

1 ○ 2 ○ 3 ○ 4 ○ 5 ○

14 The seafarers on the ship directly influence the standard of technology implementation.

Totally disagree — Strongly agree

1 ○ 2 ○ 3 ○ 4 ○ 5 ○

15	Tech/Equipment on ships are non-standardized resulting in confusion and information clutter. Totally disagree … Strongly agree 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯	16	For ease of operation, Technology on ships should be simpler to use. Totally disagree … Strongly agree 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯
17	Tech/Equipment use helps me overcome work-related fatigue. Totally disagree … Strongly agree 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯	18	Tech/Equipment use helps me overcome work-related stress. Totally disagree … Strongly agree 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯
19	Technology has made the watch-keepers' task easier Totally disagree … Strongly agree 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯	20	Implementation of Tech/Equipment leads to downsizing of crew. Totally disagree … Strongly agree 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯
21	Crew feedback on technology design/ operation is taken seriously Totally disagree … Strongly agree 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯	22	On current (last) ship man-power was suitably replaced by technology Totally disagree … Strongly agree 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯
23	On current (last) ship Technology was complex and confusing Totally disagree … Strongly agree 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯	24	Communication Technology helps the Managers monitor the ships more than it benefits the seafarers Totally disagree … Strongly agree 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯
25	Shipboard paperwork has reduced due to the implementation of Technology Totally disagree … Strongly agree 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯	26	Crew are given adequate training on technology that are used on ships Totally disagree … Strongly agree 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5 ◯

27	Please express in a few words your personal experience with Ship Technology